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Translation of PCT ARTICLE 34 Amendment

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VOLUNTARY AMENDMENT

(AMENDMENT UNDER PROVISIONS OF LAW, ARTICLE 11)

To: Japan Patent Office Examiner: Yoichi Sato

1 INDICATION OF INTERNATIONAL APPLICATION
PCT/JP2005/003805

2. APPLICANT
Name: Nippon Steel Corporation
Address: 6-3, Otemachi 2-chome, Chiyoda-ku, Tokyo, 100-8071 Japan
Nationality: Japan
Address: Japan

3. ATTORNEY
Name: Atsushi Aoki, registered patent attorney (9975)
Address: A. Aoki, Ishida & Associates
Toranomon 37 Mori Bldg., 5-1, Toranomon 3-chome, Minato-ku, Tokyo 105-8423 Japan, Telephone 03-5470-1900

4. SCOPE OF AMENDMENT
(1) Description
(2) Claims

5. CONTENT OF AMENDMENT

1) In the Description, page 3, line 23 to line 24, we amend "Al: 0.01 to 1.8%" to "Al: 0.25 to 1.8%".

2) In the Description, page 4, line 4 to line 5, we delete "further contains Al, by mass%, of 0.25 to 1.8% in range and in that".

3) In the Description, page 4, line 18 to line 19, we amend "Al: 0.01 to 1.8%" to "Al: 0.25 to 1.8%".

4) In the Description, page 5, line 23 to line 25, we delete "further contains Al, by mass%, of 0.25 to 1.8% in range and in that"

5) In the Description, page 7, line 16 to line 18, we amend "from the viewpoint of improving the ductility, Al has to be included in an amount of 0.01% or more" to "from the viewpoint of improving the ductility, Al has to be included in an amount of 0.25% or more".

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6) In the Description, page 7, line 22 to line 24, we delete "From the viewpoint of securing the steel sheet strength, addition of 0.25% to 1.8% is preferable".

7) In the Description, page 16, Table 1/Ingredients, we delete Steel types A, B and amend the table as in the attachment.

8) In the Description, page 17, Table 1 (continued), we delete Steel types A, B and amend the table as in the attachment.

9) In the Description, page 18, Table 2/Method of Production (1), we delete Experiment numbers 1, 2 and amend the table as in the attachment.

10) In the Description, page 19, Table 2 (continued), we delete Experiment numbers 1, 2 and amend the table as in the attachment.

11) In the Description, page 20, Table 3/Method of Production (2), we delete Experiment numbers 1, 2 and amend the table as in the attachment.

12) In the Description, page 21, Table 3 (continued), we delete Experiment numbers 1, 2 and amend the table as in the attachment.

13) In the Claims, page 24, claim 3, line 24 to line 25, we delete "further contains Al, by mass%, of 0.25 to 1.8% in range and in that".

14) In the Claims, page 25, claim 4, line 1 to line 2, we amend "Al: 0.01 to 1.8%" to "Al: 0.25 to 1.8%".

15) In the Claims, page 26, claim 8, line 7, we delete "further contains Al, by mass%, of 0.25 to 1.8% in range and in that".

6. LIST OF ATTACHED DOCUMENTS

(1) New page for Description, page 3, one copy
(2) New page for Description, page 4, one copy
(3) New page for Description, page 5, one copy
(4) New page for Description, page 7, one copy
(5) New page for Description, page 16, one copy
(6) New page for Description, page 17, one copy
(7) New page for Description, page 18, one copy

(8) New page for Description, page 19, one copy

(9) New page for Description, page 20, one copy

(10) New page for Description, page 21, one copy

(11) New page for Claims, page 24, one copy

(12) New page for Claims, page 25, one copy

(13) New page for Claims, page 26, one copy

elongation, and that by applying the necessary heat treatment after the hot dip galvanization step, a material stable in hole enlargement ability and embrittlement can be obtained. The inventors discovered that in steel sheet designed based on this technical idea, by making low yield stress DP steel a metal structure mainly comprised of ferrite in accordance with the conventional residual austenite steel and tempered martensite with an area rate of 5% to 60%, it is possible to secure an elongation greater than before and obtain a DP structure excellent in hole enlargement ability and optimal for hot dip galvanization.

Further, in the present invention, to prevent delayed fracture and secondary embrittlement or other problems from occurring, the unavoidably included 5% or less residual austenite may be allowed. The present invention is based on the above technical idea and has as its gist the following:

(1) A hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability characterized by containing, by mass%, C: 0.01 to 0.3%, Si: 0.005 to 0.6%, Mn: 0.1 to 3.3%, P: 0.001 to 0.06%, S:0.001 to 0.01%, Al: 0.25 to 1.8%, and N: 0.0005 to 0.01% and having a balance of Fe and unavoidable impurities, wherein the metal structure is comprised of ferrite and, by area ratio, 5% to 60% of tempered martensite.

(2) A hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in (1), characterized in that said hot dip galvanized composite high strength steel sheet further contains, by mass%, one or more of Mo: 0.05 to 0.5%, V: 0.01 to 0.1%, Ti: 0.01 to 0.2%, Nb: 0.005 to 0.05%, Cu: 1.0% or less, Ni: 1.0% or less, Cr: 1.0% or less, Ca: 0.0003 to 0.005%, REM: 0.0003 to 0.005%, and B: 0.0003 to 0.002%.

(3) A hot dip galvanized composite high strength

steel sheet excellent in shapeability and hole enlargement ability as set forth in (1) or (2), characterized in that said hot dip galvanized composite high strength steel sheet the mass% of Si and Al and the target tensile strength (TS) satisfy the following equation 1:

$$(0.0012\times[\text{TS target value}]-0.29-[\text{Si}])/1.45<\text{Al}<1.5-3\times[\text{Si}] \ldots \text{ equation 1}$$

[TS target value]: Design value of tensile strength of steel sheet (MPa), [Si]: Si mass%, Al: Al mass%

(4) A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability characterized by hot rolling, then cold rolling a slab containing, by mass%, C: 0.01 to 0.3%, Si: 0.005 to 0.6%, Mn: 0.1 to 3.3%, P: 0.001 to 0.06%, S:0.001 to 0.01%, Al: 0.25 to 1.8%, and N: 0.0005 to 0.01% and having a balance of Fe and unavoidable impurities, heating the sheet in a hot dip galvanization heating step to $Ac_1$ to $Ac_3$+100°C in temperature, holding it there for 30 seconds to 30 minutes, then cooling it by a 1°C/s or higher cooling rate to 450 to 600°C in temperature, then hot dip galvanizing it at that temperature, then cooling it by a 1°C/s or higher cooling rate to the martensite transformation point or less in temperature, then holding it at 200°C to 500°C in temperature for 1 second to 5 minutes, then cooling it by a 5°C/s or higher cooling rate to 100°C or less so as to obtain a metal structure comprised of ferrite and of tempered martensite of an area rate of 5% to 60%.

(5) A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in (4), characterized by performing alloying after said hot

dip galvanization.

(6) A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in (4) or (5), characterized by said further treating a galvanized layer or galvannealed layer by one or more of a chromate treatment, inorganic coating film treatment, chemical conversion, or resin coating film treatment.

(7) A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in any one of (4) to (6), characterized in that said hot dip galvanized composite high strength steel sheet further contains, by mass%, one or more of Mo: 0.05 to 0.5%, V: 0.01 to 0.1%, Ti: 0.01 to 0.2%, Nb: 0.005 to 0.05%, Cu: 1.0% or less, Ni: 1.0% or less, Cr: 1.0% or less, Ca: 0.0003 to 0.005%, REM: 0.0003 to 0.005%, and B: 0.0003 to 0.002%.

(8) A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in any one of (4) to (7), characterized in that said hot dip galvanized composite high strength steel sheet the mass% of Si and Al and a target tensile strength (TS) satisfy the following equation 1:

$$(0.0012\times[\text{TS target value}]-0.29-[\text{Si}])/1.45<\text{Al}<1.5-3\times[\text{Si}] \quad \ldots \text{ equation 1}$$

[TS target value]: Design value of tensile strength of steel sheet (MPa), [Si]: Si mass%, Al: Al mass%

(9) A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in any one of (4) to (8), characterized by, from said cold rolling to the hot dip galvanization heating step, preplating one or more of Ni, Fe, Co, Sn, and Cu to 0.01

sheet, but if the amount of addition is large, it segregates at the grain boundary, so degrades the local ductility and simultaneously degrades the weldability, so the upper limit value of P was made 0.06%. On the other hand, the lower limit of P was made 0.001% to avoid an increase in cost of refining.

Further, S is an element forming MnS and thereby degrading the local ductility and the weldability. It is an element preferably not present in the steel, so the upper limit value was made 0.01%. The lower limit was made 0.001% to avoid an increase in cost of refining.

Al is an element required for promoting the formation of ferrite and is effective in improving the ductility. Even if a large amount is added added, it does not inhibit the hot dip galvanizability. Further, it acts as a deoxidizing element. Therefore, from the viewpoint of improving the ductility, Al has to be included in an amount of 0.25% or more, but even if Al is excessively added, its effect becomes saturated and conversely the steel becomes embrittled. Simultaneously, the hot dip galvanization ability is reduced. Therefore, the upper limit was made 1.8%.

N is an unavoidably included element, but when included in a large amount, not only is the aging effect deteriorated, but also the amount of deposition of AlN becomes greater and the effect of addition of Al is reduced, so 0.01% or less is preferably contained. Further, unnecessarily reducing the N increases the cost in the steel making process, so normally the amount of N is controlled to 0.0005% or more.

In the present invention, when further higher strength is required, to improve the plating adhesion, if adding a large amount of Al instead of Si, in particular when 0.25%≤Al≤1.8%, by making the balance of Al and Si with TS the following equation 1 in range, sufficient

TS≥980 MPa... 40% or more considered passing

Table 1/Ingredients

| Steel type | TS target | C | Si | Mn | P | S | N | Al | Mo | V |
|---|---|---|---|---|---|---|---|---|---|---|
| C | 480 | 0.018 | 0.176 | 1.31 | 0.032 | 0.005 | 0.0070 | 0.810 | | |
| D | 500 | 0.018 | 0.112 | 2.35 | 0.043 | 0.006 | 0.0100 | 0.990 | | |
| E | 540 | 0.027 | 0.074 | 2.87 | 0.016 | 0.003 | 0.0050 | 0.430 | | |
| F | 550 | 0.030 | 0.177 | 1.11 | 0.016 | 0.009 | 0.0050 | 0.950 | | |
| G | 560 | 0.032 | 0.186 | 2.78 | 0.029 | 0.006 | 0.0030 | 0.930 | | |
| H | 570 | 0.044 | 0.100 | 2.34 | 0.039 | 0.002 | 0.0080 | 0.300 | | |
| I | 580 | 0.058 | 0.171 | 2.06 | 0.056 | 0.007 | 0.0030 | 0.970 | | |
| J | 580 | 0.058 | 0.160 | 0.17 | 0.033 | 0.002 | 0.0080 | 0.900 | 0.180 | |
| K | 590 | 0.071 | 0.196 | 1.42 | 0.037 | 0.003 | 0.0050 | 0.550 | | |
| L | 640 | 0.082 | 0.089 | 1.15 | 0.016 | 0.004 | 0.0050 | 1.140 | | |
| M | 680 | 0.082 | 0.081 | 2.93 | 0.040 | 0.001 | 0.0030 | 1.050 | | |
| N | 700 | 0.093 | 0.055 | 1.84 | 0.007 | 0.006 | 0.0070 | 0.500 | | |
| O | 760 | 0.100 | 0.013 | 0.70 | 0.002 | 0.080 | 0.0040 | 0.810 | | |
| P | 780 | 0.110 | 0.122 | 2.64 | 0.057 | 0.009 | 0.0020 | 0.730 | | |
| Q | 800 | 0.120 | 0.084 | 0.17 | 0.010 | 0.010 | 0.0040 | 0.870 | | |
| R | 840 | 0.120 | 0.148 | 0.19 | 0.016 | 0.008 | 0.0060 | 1.000 | | |
| S | 900 | 0.134 | 0.047 | 0.19 | 0.042 | 0.010 | 0.0070 | 1.110 | | |
| T | 920 | 0.140 | 0.042 | 1.71 | 0.021 | 0.006 | 0.0050 | 0.780 | | |
| U | 950 | 0.144 | 0.076 | 0.89 | 0.033 | 0.011 | 0.0060 | 0.580 | 0.190 | |
| V | 950 | 0.142 | 0.116 | 0.27 | 0.046 | 0.007 | 0.0060 | 0.850 | 0.250 | |
| W | 980 | 0.147 | 0.122 | 0.92 | 0.035 | 0.009 | 0.0070 | 0.680 | 0.270 | |
| X | 980 | 0.150 | 0.107 | 1.76 | 0.059 | 0.006 | 0.0090 | 0.880 | | |
| Y | 1280 | 0.210 | 0.153 | 1.20 | 0.025 | 0.005 | 0.0020 | 0.780 | | |
| Z | 1320 | 0.235 | 0.176 | 2.73 | 0.051 | 0.008 | 0.0040 | 0.850 | | |
| AA | 950 | 0.122 | 0.275 | 0.27 | 0.046 | 0.007 | 0.0060 | 0.650 | | |
| AB | 1180 | 0.152 | 0.118 | 1.95 | 0.055 | 0.008 | 0.0090 | 0.720 | 0.280 | |
| AC | 1180 | 0.150 | 0.107 | 2.99 | 0.059 | 0.006 | 0.0090 | 0.880 | | |
| AD | 1200 | 0.210 | 0.299 | 1.20 | 0.025 | 0.005 | 0.0020 | 0.600 | | 0.050 |
| AE | 1350 | 0.250 | 0.233 | 1.36 | 0.039 | 0.009 | 0.0080 | 0.750 | 0.270 | |
| AF | 1480 | 0.289 | 0.186 | 2.06 | 0.052 | 0.004 | 0.0080 | 0.910 | | |
| AG | 780 | 0.095 | 0.247 | 2.09 | 0.008 | 0.007 | 0.0029 | 0.892 | | |
| AH | 780 | 0.101 | 0.226 | 2.68 | 0.006 | 0.008 | 0.0080 | 1.712 | | |
| AI | 1130 | 0.261 | 0.276 | 0.43 | 0.043 | 0.009 | 0.0090 | 0.815 | | 0.050 |
| AJ | 1470 | 0.300 | 0.289 | 0.47 | 0.038 | 0.005 | 0.0005 | 1.391 | | |
| AK | 1570 | 0.295 | 0.395 | 0.52 | 0.040 | 0.004 | 0.0032 | 0.212 | 0.150 | |
| AL | 1570 | 0.298 | 0.526 | 0.88 | 0.049 | 0.006 | 0.0069 | 0.106 | | |
| AM | 310 | 0.009 | 0.202 | 0.43 | 0.007 | 0.010 | 0.0063 | 1.778 | | |
| AN | 1570 | 0.320 | 0.113 | 2.92 | 0.003 | 0.006 | 0.0007 | 0.462 | | |
| AO | 980 | 0.166 | 0.607 | 2.64 | 0.056 | 0.009 | 0.0049 | 0.422 | | 0.050 |
| AP | 880 | 0.113 | 0.083 | 0.09 | 0.049 | 0.001 | 0.0006 | 0.527 | | |
| AQ | 1180 | 0.164 | 0.285 | 3.44 | 0.020 | 0.004 | 0.0041 | 1.247 | 0.072 | |
| AR | 780 | 0.125 | 0.267 | 2.06 | 0.070 | 0.003 | 0.0009 | 0.337 | | |
| AS | 540 | 0.058 | 0.131 | 2.50 | 0.002 | 0.020 | 0.0059 | 0.377 | | |
| AT | 540 | 0.026 | 0.145 | 0.15 | 0.011 | 0.010 | 0.0200 | 0.273 | | |
| AU | 720 | 0.099 | 0.188 | 0.45 | 0.046 | 0.002 | 0.0030 | 0.009 | | |
| AV | 880 | 0.130 | 0.186 | 2.39 | 0.051 | 0.006 | 0.0030 | 2.010 | | |

Table 1 (continued)

| Steel type | Ti | Nb | Cu | Ni | Cr | Ca | B | REM | Class |
|---|---|---|---|---|---|---|---|---|---|
| C | | 0.040 | | | | | | | Inv. ingr. |
| D | 0.040 | | | | | | | | Inv. ingr. |
| E | | | | | | | | | Inv. ingr. |
| F | | | | | | | | | Inv. ingr. |
| G | | | | | | | | | Inv. ingr. |
| H | | | | | | | | | Inv. ingr. |
| I | | | | | | | | | Inv. ingr. |
| J | | | | | | | | | Inv. ingr. |
| K | | | | | | | | | Inv. ingr. |
| L | | | | | | | | 0.0020 | Inv. ingr. |
| M | | | | | | | 0.0010 | | Inv. ingr. |
| N | | | | | | | | | Inv. ingr. |
| O | | | | | | 0.0030 | | | Inv. ingr. |
| P | | | | | | | | | Inv. ingr. |
| Q | | | | | 0.060 | | | | Inv. ingr. |
| R | | | | | | | | | Inv. ingr. |
| S | | | 0.010 | 0.010 | | | | | Inv. ingr. |
| T | | | | | | | | | Inv. ingr. |
| U | | | | | | | | | Inv. ingr. |
| V | | | | | | | | | Inv. ingr. |
| W | | | | | | | | | Inv. ingr. |
| X | | | | | | | | | Inv. ingr. |
| Y | | | | | | | | | Inv. ingr. |
| Z | | 0.020 | | | | | | | Inv. ingr. |
| AA | | | | | | | | | Inv. ingr. |
| AB | | | | | | | | | Inv. ingr. |
| AC | 0.060 | | | | | | | | Inv. ingr. |
| AD | | | | | | | | | Inv. ingr. |
| AE | | | | | | | | | Inv. ingr. |
| AF | | | | | | | | | Inv. ingr. |
| AG | | | | | | | | | Inv. ingr. |
| AH | | | | | | | | | Inv. ingr. |
| AI | | | | | | | | | Inv. ingr. |
| AJ | | | | | | | | | Inv. ingr. |
| AK | 0.045 | | | | | | | | Inv. ingr. |
| AL | | | 0.030 | 0.040 | | | | | Inv. ingr. |
| AM | | | | | | | | | Comp. ingr. |
| AN | | | 0.020 | 0.025 | | | | 0.0030 | Comp. ingr. |
| AO | | | | | | 0.0030 | | | Comp. ingr. |
| AP | 0.022 | 0.027 | | | | | 0.0010 | | Comp. ingr. |
| AQ | | | | | | | | | Comp. ingr. |
| AR | | | | | | | | | Comp. ingr. |
| AS | | 0.023 | | | 0.025 | | | | Comp. ingr. |
| AT | | | | | | | | | Comp. ingr. |
| AU | | | | | | | | | Comp. ingr. |
| AV | | | | | | | | | Comp. ingr. |

Table 2/Method of Production (1)

| Exper. no. | Steel type | TS (MPa) | EL (%) | TSxEL | (A) equation | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | TS target value (MPa) | (A) equation left side | Al | (A) equation right side | (A) equation judgment |
| 3 | C | 476 | 37.9 | 18040 | 480 | 0.076 | 0.810 | 0.972 | Good |
| 4 | D | 508 | 36.9 | 18745 | 500 | 0.137 | 0.990 | 1.164 | Good |
| 5 | E | 551 | 33.0 | 18183 | 540 | 0.196 | 0.430 | 1.278 | Good |
| 6 | F | 549 | 33.1 | 18172 | 550 | 0.133 | 0.950 | 0.969 | Good |
| 7 | G | 568 | 32.5 | 18460 | 560 | 0.135 | 0.930 | 0.942 | Good |
| 8 | H | 582 | 31.9 | 18566 | 570 | 0.203 | 0.300 | 1.200 | Good |
| 9 | I | 591 | 30.9 | 18262 | 580 | 0.162 | 0.970 | 0.987 | Good |
| 10 | J | 584 | 31.2 | 18221 | 580 | 0.170 | 0.900 | 1.020 | Good |
| 11 | K | 605 | 29.9 | 18090 | 590 | 0.153 | 0.550 | 0.912 | Good |
| 12 | L | 632 | 30.1 | 19023 | 640 | 0.268 | 1.140 | 1.233 | Good |
| 13 | M | 688 | 28.7 | 19746 | 680 | 0.307 | 1.050 | 1.257 | Good |
| 14 | N | 695 | 27.2 | 18904 | 700 | 0.341 | 0.500 | 1.335 | Good |
| 15 | O | 743 | 24.8 | 18426 | 760 | 0.420 | 0.810 | 1.461 | Good |
| 16 | P | 812 | 23.2 | 18838 | 780 | 0.361 | 0.730 | 1.134 | Good |
| 17 | Q | 825 | 22.8 | 18810 | 800 | 0.404 | 0.870 | 1.248 | Good |
| 18 | R | 852 | 21.5 | 18318 | 840 | 0.393 | 1.000 | 1.056 | Good |
| 19 | S | 905 | 20.1 | 18191 | 900 | 0.512 | 1.110 | 1.359 | Good |
| 20 | T | 899 | 20.5 | 18430 | 920 | 0.532 | 0.780 | 1.374 | Good |
| 21 | U | 952 | 19.0 | 18088 | 950 | 0.534 | 0.580 | 1.272 | Good |
| 22 | V | 934 | 19.5 | 18213 | 950 | 0.506 | 0.850 | 1.152 | Good |
| 23 | W | 987 | 19.1 | 18852 | 980 | 0.527 | 0.680 | 1.134 | Good |
| 24 | X | 1024 | 18.2 | 18637 | 980 | 0.537 | 0.880 | 1.179 | Good |
| 25 | Y | 1320 | 14.9 | 19668 | 1280 | 0.754 | 0.780 | 1.041 | Good |
| 26 | Z | 1400 | 13.5 | 18900 | 1320 | 0.771 | 0.850 | 0.972 | Good |
| 27 | AA | 965 | 19.9 | 19204 | 950 | 0.397 | 0.650 | 0.675 | Good |
| 28 | AB | 1206 | 15.2 | 18331 | 1180 | 0.695 | 0.720 | 1.146 | Good |
| 29 | AC | 1230 | 15.8 | 19434 | 1180 | 0.703 | 0.880 | 1.179 | Good |
| 30 | AD | 1220 | 15.3 | 18666 | 1200 | 0.587 | 0.600 | 0.603 | Good |
| 31 | AE | 1364 | 13.4 | 18278 | 1350 | 0.757 | 0.750 | 0.801 | Poor |
| 32 | AF | 1520 | 12.2 | 18544 | 1480 | 0.897 | 0.910 | 0.942 | Good |
| 33 | AG | 795 | 22.5 | 17888 | 780 | 0.275 | 0.892 | 0.759 | Poor |
| 34 | AH | 825 | 20.9 | 17243 | 780 | 0.290 | 1.712 | 0.822 | Poor |
| 35 | AI | 1158 | 15.1 | 17486 | 1130 | 0.545 | 0.815 | 0.672 | Poor |
| 36 | AJ | 1476 | 12.2 | 18007 | 1470 | 0.817 | 1.391 | 0.633 | Poor |
| 37 | AK | 1584 | 11.4 | 18058 | 1570 | 0.827 | 0.212 | 0.315 | Poor |
| 38 | AL | 1603 | 11.3 | 18114 | 1570 | 0.737 | 0.106 | -0.078 | Poor |
| 39 | AM | 335 | 33.2 | 11122 | 310 | -0.083 | 1.778 | 0.894 | Poor |
| 40 | AN | 1623 | 7.8 | 12659 | 1570 | 1.021 | 0.462 | 1.161 | Poor |
| 41 | AO | 985 | 17.5 | 17238 | 980 | 0.192 | 0.422 | -0.321 | Poor |
| 42 | AP | 885 | 18.5 | 16373 | 880 | 0.471 | 0.527 | 1.251 | Good |
| 43 | AQ | 1235 | 10.2 | 12597 | 1180 | 0.580 | 1.247 | 0.645 | Poor |
| 44 | AR | 795 | 20.1 | 15980 | 780 | 0.261 | 0.337 | 0.699 | Good |
| 45 | AS | 587 | 26.5 | 15556 | 540 | 0.157 | 0.377 | 1.107 | Good |
| 46 | AT | 557 | 31.2 | 17378 | 540 | 0.147 | 0.273 | 1.065 | Good |
| 47 | AU | 750 | 22.2 | 16650 | 720 | 0.266 | 0.009 | 0.936 | Poor |
| 48 | AV | 899 | 18.6 | 16721 | 880 | 0.400 | 2.010 | 0.942 | Poor |

Table 2 (continued)

| Experiment no. | Tempered martensite area (%) | Hole enlargement rate (%) | Plating adhesion | Plating appearance | Class |
|---|---|---|---|---|---|
| 3 | <5% | 73 | Good | Very good | Comp. ex. |
| 4 | <5% | 70 | Very good | Very good | Comp. ex. |
| 5 | <5% | 66 | Very good | Very good | Comp. ex. |
| 6 | <5% | 65 | Good | Very good | Comp. ex. |
| 7 | <5% | 63 | Good | Very good | Comp. ex. |
| 8 | <5% | 61 | Very good | Very good | Comp. ex. |
| 9 | <5% | 60 | Good | Good | Comp. ex. |
| 10 | <5% | 62 | Good | Good | Comp. ex. |
| 11 | <5% | 58 | Good | Very good | Comp. ex. |
| 12 | <5% | 60 | Very good | Very good | Comp. ex. |
| 13 | <5% | 58 | Very good | Very good | Comp. ex. |
| 14 | <5% | 56 | Very good | Very good | Comp. ex. |
| 15 | <5% | 55 | Very good | Very good | Comp. ex. |
| 16 | <5% | 54 | Good | Very good | Comp. ex. |
| 17 | <5% | 53 | Very good | Very good | Comp. ex. |
| 18 | <5% | 51 | Good | Very good | Comp. ex. |
| 19 | <5% | 50 | Very good | Very good | Comp. ex. |
| 20 | <5% | 49 | Very good | Very good | Comp. ex. |
| 21 | <5% | 44 | Good | Very good | Comp. ex. |
| 22 | <5% | 47 | Good | Very good | Comp. ex. |
| 23 | <5% | 46 | Good | Very good | Comp. ex. |
| 24 | <5% | 45 | Good | Very good | Comp. ex. |
| 25 | <5% | 38 | Good | Good | Comp. ex. |
| 26 | <5% | 37 | Good | Good | Comp. ex. |
| 27 | <5% | 48 | Good | Good | Comp. ex. |
| 28 | <5% | 39 | Good | Good | Comp. ex. |
| 29 | <5% | 41 | Very good | Very good | Comp. ex. |
| 30 | <5% | 40 | Good | Good | Comp. ex. |
| 31 | <5% | 37 | Good | Good | Comp. ex. |
| 32 | <5% | 35 | Good | Good | Comp. ex. |
| 33 | <5% | 54 | Good | Good | Comp. ex. |
| 34 | <5% | 52 | Good | Good | Comp. ex. |
| 35 | <5% | 41 | Good | Good | Comp. ex. |
| 36 | <5% | 35 | Good | Good | Comp. ex. |
| 37 | <5% | 34 | Good | Good | Comp. ex. |
| 38 | <5% | 33 | Good | Good | Comp. ex. |
| 39 | <5% | 64 | Good | Good | Comp. ex. |
| 40 | <5% | 27 | Good | Very good | Comp. ex. |
| 41 | <5% | 47 | Fair | Fair | Comp. ex. |
| 42 | <5% | 45 | Very good | Very good | Comp. ex. |
| 43 | <5% | 30 | Fair | Fair | Comp. ex. |
| 44 | <5% | 50 | Good | Good | Comp. ex. |
| 45 | <5% | 56 | Good | Very good | Comp. ex. |
| 46 | <5% | 60 | Good | Very good | Comp. ex. |
| 47 | <5% | 50 | Good | Good | Comp. ex. |
| 48 | <5% | 49 | Poor | Poor | Comp. ex. |

Table 3/Method of Production (2)

| Exper. no. | Steel type | TS (MPa) | EL (%) | TSxEL | (A) equation: TS target value (*) (MPa) | (A) equation: (A) equation left side | (A) equation: Al | (A) equation: (A) equation right side | (A) equation: (A) equation judgment |
|---|---|---|---|---|---|---|---|---|---|
| 3 | C | 443 | 42.4 | 18791 | 440 | 0.043 | 0.810 | 0.972 | Good |
| 4 | D | 467 | 40.2 | 18798 | 460 | 0.103 | 0.990 | 1.164 | Good |
| 5 | E | 501 | 36.3 | 18201 | 500 | 0.163 | 0.430 | 1.278 | Good |
| 6 | F | 511 | 37.1 | 18928 | 510 | 0.100 | 0.950 | 0.969 | Good |
| 7 | G | 523 | 35.4 | 18512 | 520 | 0.102 | 0.930 | 0.942 | Good |
| 8 | H | 530 | 35.1 | 18584 | 530 | 0.170 | 0.300 | 1.200 | Good |
| 9 | I | 550 | 34.6 | 19022 | 540 | 0.129 | 0.970 | 0.987 | Good |
| 10 | J | 537 | 34.0 | 18272 | 530 | 0.128 | 0.900 | 1.020 | Good |
| 11 | K | 551 | 32.9 | 18108 | 550 | 0.120 | 0.550 | 0.912 | Good |
| 12 | L | 594 | 33.7 | 20028 | 590 | 0.227 | 1.140 | 1.233 | Good |
| 13 | M | 633 | 31.3 | 19801 | 630 | 0.266 | 1.050 | 1.257 | Good |
| 14 | N | 653 | 29.9 | 19547 | 650 | 0.300 | 0.500 | 1.335 | Good |
| 15 | O | 706 | 27.8 | 19606 | 700 | 0.370 | 0.810 | 1.461 | Good |
| 16 | P | 747 | 25.3 | 18891 | 740 | 0.328 | 0.730 | 1.134 | Good |
| 17 | Q | 767 | 25.1 | 19243 | 760 | 0.371 | 0.870 | 1.248 | Good |
| 18 | R | 809 | 24.1 | 19490 | 800 | 0.360 | 1.000 | 1.056 | Good |
| 19 | S | 860 | 22.3 | 19182 | 860 | 0.479 | 1.110 | 1.359 | Good |
| 20 | T | 863 | 23.2 | 19992 | 860 | 0.483 | 0.780 | 1.374 | Good |
| 21 | U | 895 | 21.1 | 18873 | 890 | 0.484 | 0.580 | 1.272 | Good |
| 22 | V | 897 | 22.4 | 20107 | 890 | 0.457 | 0.850 | 1.152 | Good |
| 23 | W | 928 | 21.2 | 19670 | 920 | 0.477 | 0.680 | 1.134 | Good |
| 24 | X | 922 | 20.2 | 18618 | 920 | 0.488 | 0.880 | 1.179 | Good |
| 25 | Y | 1228 | 16.8 | 20669 | 1220 | 0.704 | 0.780 | 1.041 | Good |
| 26 | Z | 1274 | 15.5 | 19779 | 1260 | 0.721 | 0.850 | 0.972 | Good |
| 27 | AA | 907 | 22.1 | 20037 | 890 | 0.347 | 0.650 | 0.675 | Good |
| 28 | AB | 1134 | 16.9 | 19127 | 1120 | 0.646 | 0.720 | 1.146 | Good |
| 29 | AC | 1132 | 17.9 | 20204 | 1120 | 0.653 | 0.880 | 1.179 | Good |
| 30 | AD | 1147 | 17.6 | 20178 | 1140 | 0.537 | 0.600 | 0.603 | Good |
| 31 | AE | 1296 | 14.9 | 19274 | 1290 | 0.707 | 0.750 | 0.801 | Good |
| 32 | AF | 1429 | 13.5 | 19349 | 1420 | 0.847 | 0.910 | 0.942 | Good |
| 33 | AG | 731 | 25.4 | 18596 | 730 | 0.234 | 0.892 | 0.759 | Poor |
| 34 | AH | 751 | 24.0 | 18044 | 740 | 0.257 | 1.712 | 0.822 | Poor |
| 35 | AI | 1077 | 17.4 | 18701 | 1070 | 0.495 | 0.815 | 0.672 | Poor |
| 36 | AJ | 1402 | 13.8 | 19331 | 1400 | 0.759 | 1.391 | 0.633 | Poor |
| 37 | AK | 1457 | 12.7 | 18440 | 1450 | 0.728 | 0.212 | 0.315 | Poor |
| 38 | AL | 1459 | 12.5 | 18297 | 1450 | 0.637 | 0.106 | -0.078 | Poor |
| 39 | AM | 312 | 37.2 | 11585 | 300 | -0.091 | 1.778 | 0.894 | Poor |
| 40 | AN | 1493 | 8.5 | 12695 | 1490 | 0.955 | 0.462 | 1.161 | Poor |
| 41 | AO | 896 | 19.3 | 17255 | 890 | 0.118 | 0.422 | -0.321 | Poor |
| 42 | AP | 823 | 20.7 | 17054 | 820 | 0.421 | 0.527 | 1.251 | Good |
| 43 | AQ | 1136 | 11.1 | 12632 | 1120 | 0.530 | 1.247 | 0.645 | Poor |
| 44 | AR | 723 | 22.1 | 15995 | 720 | 0.212 | 0.337 | 0.699 | Good |
| 45 | AS | 546 | 29.7 | 16203 | 540 | 0.157 | 0.377 | 1.107 | Good |
| 46 | AT | 512 | 34.0 | 17427 | 510 | 0.122 | 0.273 | 1.065 | Good |
| 47 | AU | 683 | 24.4 | 16667 | 680 | 0.233 | 0.009 | 0.936 | Poor |
| 48 | AV | 809 | 20.3 | 16404 | 800 | 0.334 | 2.010 | 0.942 | Poor |

*: Corrected TS target value considering tempering

Table 3 (continued)

| Experiment no. | Tempered martensite area (%) | Hole enlargement rate (%) | Plating adhesion | Plating appearance | Class |
|---|---|---|---|---|---|
| 3 | 6.4 | 86 | Good | Very good | Inv. ex. |
| 4 | 6.7 | 82 | Very good | Very good | Inv. ex. |
| 5 | 7.8 | 77 | Very good | Very good | Inv. ex. |
| 6 | 9.0 | 76 | Good | Very good | Inv. ex. |
| 7 | 9.7 | 74 | Good | Very good | Inv. ex. |
| 8 | 11.4 | 72 | Very good | Very good | Inv. ex. |
| 9 | 14.6 | 71 | Good | Good | Inv. ex. |
| 10 | 13.5 | 72 | Good | Good | Inv. ex. |
| 11 | 17.2 | 68 | Good | Very good | Inv. ex. |
| 12 | 20.3 | 71 | Very good | Very good | Inv. ex. |
| 13 | 21.1 | 67 | Very good | Very good | Inv. ex. |
| 14 | 21.5 | 66 | Very good | Very good | Inv. ex. |
| 15 | 22.3 | 65 | Very good | Very good | Inv. ex. |
| 16 | 24.6 | 63 | Good | Very good | Inv. ex. |
| 17 | 21.1 | 61 | Very good | Very good | Inv. ex. |
| 18 | 21.6 | 60 | Good | Very good | Inv. ex. |
| 19 | 22.8 | 59 | Very good | Very good | Inv. ex. |
| 20 | 24.3 | 58 | Very good | Very good | Inv. ex. |
| 21 | 25.2 | 52 | Good | Very good | Inv. ex. |
| 22 | 25.0 | 56 | Good | Very good | Inv. ex. |
| 23 | 26.2 | 55 | Good | Very good | Inv. ex. |
| 24 | 25.9 | 54 | Good | Very good | Inv. ex. |
| 25 | 42.7 | 45 | Good | Good | Inv. ex. |
| 26 | 45.5 | 45 | Good | Good | Inv. ex. |
| 27 | 22.3 | 57 | Good | Good | Inv. ex. |
| 28 | 26.9 | 46 | Good | Good | Inv. ex. |
| 29 | 26.7 | 49 | Very good | Very good | Inv. ex. |
| 30 | 43.0 | 47 | Good | Good | Inv. ex. |
| 31 | 47.6 | 45 | Good | Good | Inv. ex. |
| 32 | 50.4 | 41 | Good | Good | Inv. ex. |
| 33 | 20.9 | 64 | Good | Good | Inv. ex. |
| 34 | 22.5 | 62 | Good | Good | Inv. ex. |
| 35 | 47.6 | 49 | Good | Good | Inv. ex. |
| 36 | 55.3 | 42 | Good | Good | Inv. ex. |
| 37 | 58.7 | 40 | Good | Good | Inv. ex. |
| 38 | 59.5 | 40 | Good | Good | Inv. ex. |
| 39 | <5% | 75 | Good | Good | Comp. ex. |
| 40 | 65.3 | 36 | Good | Very good | Comp. ex. |
| 41 | 31.2 | 57 | Fair | Fair | Comp. ex. |
| 42 | 25.1 | 54 | Very good | Very good | Comp. ex. |
| 43 | 38.0 | 37 | Fair | Fair | Comp. ex. |
| 44 | 21.4 | 59 | Good | Good | Comp. ex. |
| 45 | 12.1 | 66 | Good | Very good | Comp. ex. |
| 46 | 8.5 | 71 | Good | Very good | Comp. ex. |
| 47 | 22.2 | 59 | Good | Good | Comp. ex. |
| 48 | 22.4 | 57 | Poor | Poor | Comp. ex. |

As will be understood from Example 1, the invention examples described in Table 3 are increased in amount of tempered martensite over the comparative examples of the same experiment numbers described in Table 2 and therefore are improved in hole enlargement ability. Further, when equation 1 is not satisfied, while the passing condition is satisfied, compared with steel types with the same degree of TS, the elongation is poor and,

CLAIMS

1. A hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability characterized by containing, by mass%, C: 0.01 to 0.3%, Si: 0.005 to 0.6%, Mn: 0.1 to 3.3%, P: 0.001 to 0.06%, S:0.001 to 0.01%, Al: 0.01 to 1.8%, and N: 0.0005 to 0.01% and having a balance of Fe and unavoidable impurities, wherein the metal structure is comprised of ferrite and, by area ratio, 5% to 60% of tempered martensite.

2. A hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in claim 1, characterized in that said hot dip galvanized composite high strength steel sheet further contains, by mass%, one or more of Mo: 0.05 to 0.5%, V: 0.01 to 0.1%, Ti: 0.01 to 0.2%, Nb: 0.005 to 0.05%, Cu: 1.0% or less, Ni: 1.0% or less, Cr: 1.0% or less, Ca: 0.0003 to 0.005%, REM: 0.0003 to 0.005%, and B: 0.0003 to 0.002%.

3. (Amended) A hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in claim 1 or 2, characterized in that said hot dip galvanized composite high strength steel sheet the mass% of Si and Al and the target tensile strength (TS) satisfy the following equation 1:

$$(0.0012\times[\text{TS target value}]-0.29-[\text{Si}])/1.45<\text{Al}<1.5-3\times[\text{Si}] \quad \ldots \text{ equation 1}$$

[TS target value]: Design value of tensile strength of steel sheet (MPa), [Si]: Si mass%, Al: Al mass%

4. (Amended) A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability characterized by hot rolling, then cold rolling a slab containing, by mass%, C: 0.01 to 0.3%, Si: 0.005 to 0.6%, Mn: 0.1 to

3.3%, P: 0.001 to 0.06%, S:0.001 to 0.01%, Al: 0.25 to 1.8%, and N: 0.0005 to 0.01% and having a balance of Fe and unavoidable impurities, heating the sheet in a hot dip galvanization heating step to $Ac_1$ to $Ac_3$+100°C in temperature, holding it there for 30 seconds to 30 minutes, then cooling it by a 1°C/s or higher cooling rate to 450 to 600°C in temperature, then hot dip galvanizing it at that temperature, then cooling it by a 1°C/s or higher cooling rate to the martensite transformation point or less in temperature, then holding it at 200°C to 500°C in temperature for 1 second to 5 minutes, then cooling it by a 5°C/s or higher cooling rate to 100°C or less so as to obtain a metal structure comprised of ferrite and of tempered martensite of an area rate of 5% to 60%.

5. A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in claim 4, characterized by performing alloying after said hot dip galvanization.

6. A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in claim 4 or 5, characterized by said further treating a galvanized layer or galvannealed layer by one or more of a chromate treatment, inorganic coating film treatment, chemical conversion, or resin coating film treatment.

7. A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in any one of claims 4 to 6, characterized in that said hot dip galvanized composite high strength steel sheet further contains, by mass%, one or more of Mo: 0.05 to 0.5%, V: 0.01 to 0.1%, Ti: 0.01 to 0.2%, Nb: 0.005 to 0.05%, Cu: 1.0% or less, Ni: 1.0% or less, Cr: 1.0% or less, Ca: 0.0003 to 0.005%, REM: 0.0003 to 0.005%, and B:

0.0003 to 0.002%.

8. (Amended) A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in any one of claims 4 to 7, characterized in that said hot dip galvanized composite high strength steel sheet the mass% of Si and Al and a target tensile strength (TS) satisfy the following equation 1:

$$(0.0012\times[\text{TS target value}]-0.29-[\text{Si}])/1.45<\text{Al}<1.5-3\times[\text{Si}]\ldots \text{ equation 1}$$

[TS target value]: Design value of tensile strength of steel sheet (MPa), [Si]: Si mass%, Al: Al mass%

9. A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in any one of claims 4 to 8, characterized by, from said cold rolling to the hot dip galvanization heating step, preplating one or more of Ni, Fe, Co, Sn, and Cu to 0.01 to 2.0 $g/m^2$ per surface of the steel sheet.

10. A method of production of a hot dip galvanized composite high strength steel sheet excellent in shapeability and hole enlargement ability as set forth in claim 9, characterized by pickling the steel sheet before said preplating.